ICFO spotlight

SUMMER
FALL 2009 04

scientists and society

The days when scientists mostly worked in isolation from society now seem to be long gone. Today, an increasing number of researchers step out of the ivory tower to share their enthusiasm for science with schoolchildren or communicate their findings to the general public. Others transfer their scientific expertise to industry through consulting or partner with companies to develop research results into new products and services. Some also inform the public debate by talking to the press and contribute to policy-making.

Most public stakeholders and scientific circles welcome this change in scientists' participation. Today's scientists are increasingly called upon to share their knowledge with the public, educate the younger generations, and advise on the actions to be taken to curb the world's ills. How much individual scientists can really contribute to such activities depends on many factors, including their research field and personal inclination, but the scientific community as a whole has a lot to offer to society beyond pushing the boundaries of knowledge.

This latest issue of ICFO Spotlight is replete with evidence of such society-minded activities. Over the summer, many young researchers at ICFO dedicated some of their time to introducing schoolchildren and teenagers to the wonders of light through talks, demonstrations of optics experiments, and participation in summer schools. ICFO group leader Antonio Acín also gave a talk at the Museum of Contemporary Art of Barcelona, demystifying a subject as complex as randomness and uncertainty in quantum mechanics for a lay audience.

In yet another initiative, a group of young scientists at ICFO have launched an independent magazine, called Optics & Photonics Focus (OPFocus), to highlight and analyze important scientific developments in the field. Their goal: to make new research findings in optics and photonics accessible to fellow scientists, journalists, and the general public.

Finally, ICFO group leader Romain Quidant has entered a partnership with local company Endor Nanotechnologies with the objective of putting on the market a new way of understanding cosmetics. ICFO Ph.D. students and postdocs also studied away from the lab for a few days to hone their business skills with ESADE Business School professors during the 'From Science to Business Week'. Their motivations for taking part in the workshop ranged from sheer curiosity about the industry world to the hope to one day launch a spin-off company.

But also, in this latest issue of ICFO Spotlight, you will again find many fine examples of scientific research. Ultimately, while today's researchers can contribute to society in many more ways than before, the primary passion for them all remains the science.

Enjoy your reading.

Elisabeth Pain – ICFO Spotlight Coordinating Editor

index

cover

The '2009 ICFO's Cycling, Hiking, and Canyoning Tour' took ICFOnians on an adventure trip to the Terra Alta near Tarragona, Catalonia in September. After a whole day biking on a former railway track going from Horta de Sant Joan to Xerta, Tour participants went on to experience the thrills of hiking and canyoning together.

ICFO
Institut de Ciències Fotòniques

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HAPPENINGS

ICFO news

New Collaboration with Mexico
ICFO has now entered a collaboration that counts with Mexican research institutions as partners. Following the new agreement, signed in August, ICFO, the University of Oxford in the United Kingdom, and the Centre for Research and Technology Hellas in Thessaloniki, Greece will work on a joint research project with the National Autonomous University of Mexico (UNAM), the University of Guanajuato, and the Centre for Scientific Research and Higher Education of Ensenada, Baja California (CICESE). The Mexican telecom company Iusacell PCS and industrial group Servicios Condumex will also contribute to the project, which aims to develop new quantum mechanics applications in information technology.
Alfred U'Ren of UNAM will coordinate the project, with ICFO group leader Juan P. Torres coordinating ICFO's participation. The 2-year collaboration is one of 21 research projects supported by the Mexican funding agency FONCYCIT to promote cooperation between Mexican and European research institutions.

New Group Leaders Appointments
Frank Koppens will start a new position of junior group leader at ICFO in October to run a research program at the interface of nano-optoelectronics, plasmonics, and solid-state quantum information processing. Frank Koppens obtained a Ph.D. in nanoscience and quantum computation from the Kavli Institute of Nanoscience in Delft, the Netherlands in 2007 before becoming a postdoctoral fellow at Harvard University in Cambridge, in the United States.
In September, Gerasimos Konstantatos also joined ICFO as a junior group leader to explore novel nanomaterials and devices for renewable energy applications. Gerasimos Konstantatos received a Ph.D. in electrical and computer engineering in 2008 from the University of Toronto, Canada, where he also pursued training as a postdoc.
In July, Group Leader Romain Quidant was awarded tenure at ICFO to continue his research in the field of nano-optics.

LPHYS and BEC 2009
With more than 560 attendees, 540 oral contributions, and 130 posters, this year's International Laser Physics Workshop (LPHYS) hit a record high in participation and scientific exchange in its 18-year history. LPHYS'09 was held by ICFO in July at the World Trade Center in Barcelona. The event was co-chaired by ICFO group leader Jens Biegert and Pavel Pashinin, of the A.M. Prokhorov General Physics Institute in Moscow, Russia. The workshop offered seminars on modern trends in laser physics, strong field and attosecond physics, biophotonics, physics of lasers, nonlinear optics and spectroscopy, physics of cold trapped atoms, quantum information science, nanophotonics, and fiber lasers.
In September, ICFO also co-organized the Bose-Einstein Condensation (BEC) 2009 conference on research frontiers in quantum gases at Sant Feliu de Guíxols. ICFO group leader Maciej Lewenstein acted as local scientific organizer and also ran the satellite 'ICREA Workshop on Quantum Gauge Theories and Ultracold Atoms.'

Scientific outreach
The ICFO Organization and Network of Students (ICONS) recently organized another two of their 'Days of Light'--science workshops that introduce teenagers to the wonders of light through talks and everyday life optics experiments. While one 'Day of Light' welcomed students from the Puig de la Creu secondary school in Castellar del Vallès at ICFO, the other was addressed to elementary schoolchildren for the first time. This second 'Day of Light' was run at the Escaan International School in Sitges.
ICFO group leader Antonio Acín also recently demystified randomness and uncertainty in quantum mechanics for a lay audience at the Museum of Contemporary Art of Barcelona (MACBA). The counter-intuitive science subject is a cornerstone of quantum information theory, which could lead to many important applications, like the development of secure data transmission for example.
In July, plasmonic oncology research performed at ICFO by Romain Quidant and his team was highlighted during prime-time evening news on the Spanish national TVE1 channel.

ICFO newcomers

A warm welcome to all of you who joined ICFO between June and August this year!


Alba Alfonso
Undergraduate Student


Alejandro Zamora
Ph.D. Student


Ana Belén Sainz
Ph.D. Student


Ángel López
IT Technician


Olga Borovkova
Ph.D. Student


Séverine Philippe
Postdoctoral Researcher


Sinéad Kennedy
Strategic Projects (KTT)


Tong Lai Chen
Postdoctoral Researcher


Augusto Roncaglia
Postdoctoral Researcher


Jonathan Palero
Postdoctoral Researcher


Michael Geiselmann
Ph.D. Student


Olga Malinkiewicz
Research Engineer


Udo Weigel
Research Fellow


Valery Lobanov
Visiting Scientist


Yannick Lefevre
Postgraduate Student


Zackaria Mahfoud
Postgraduate Student

welcome to ICFO

LATEST ADVANCES

research highlights

Efficient Quantum Communication in Space
One promising way to one day exchange secure information in space is to harness quantum physics to encrypt messages. The peculiar ability of photons to come into entangled pairs could be used to reveal the presence of eavesdroppers during the transmission of messages between ground and space stations. ICFO has now entered a new project spearheaded by the European Space Agency (ESA) to design more efficient sources of entangled photons. ICFO Group Leader Valerio Pruneri is coordinator of the EQUO (Entangled photon source for QUantum cOmmunications) project, with additional research expertise from Morgan Mitchell, Juan P. Torres, and their groups. Also taking part in the project are the LMU University-Max Planck Institute and the company qutools GmbH in Munich, Germany, the University of Bristol, England, and the University of Vienna, Austria. The initiative complements an existing ESA project, also scientifically coordinated by ICFO, that aims to develop a quantum transceiver for space applications.

Optical Frequency Conversion with BIBO
ICFO group leader Majid Ebrahim-Zadeh, Valentin Petrov of the Max-Born Institute for Nonlinear Optics and Ultrafast Spectroscopy in Berlin, Germany, and colleagues recapped recent findings on the inorganic crystal BiB_3O_6 (BIBO) in an invited review published online in Laser & Photonics Reviews (LPR), in June. BIBO is a material that is able to change the frequency of incoming light waves by means of nonlinear optical phenomena. The review, entitled, 'Femtosecond nonlinear frequency conversion based on BiB_3O_6', details the optical properties that make BIBO an attractive crystal candidate for nonlinear frequency conversion of laser light, using ultrafast femtosecond laser sources in particular. To date, BIBO is the first low-symmetry inorganic nonlinear crystal to be known, and a broad range of applications have been found since its unique optical properties were first demonstrated.

Optical Monitoring in Stroke Patients
Ischemic stroke, the loss of brain function due to a sudden lack of blood and oxygen supply, is one of the leading causes of death and disability in Europe and in the United States. Among the objectives of ICFO group leader Turgut Durduran is to design better ways to perform non-invasive measurements of cerebral blood flow in stroke patients. In a research paper highlighted recently in the Virtual Journal of Biomedical Optics, Turgut Durduran and colleagues at the University of Pennsylvania in the United States simultaneously measured blood flow, hemoglobin concentration, and level of oxygenation in patients' brains. This was made possible by the combination of two different optical monitoring techniques, namely diffuse correlation spectroscopy and near-infrared spectroscopy. The research was led by Turgut Durduran at the University of Pennsylvania before he joined ICFO earlier this year.

New Organic Light-Emitting Diodes
Organic light-emitting diodes (OLEDs) offer great potential in lowering the manufacturing costs and increasing the quality of many everyday life products like cell phones, TV screens, and computer displays. OLEDs have traditionally relied on transparent electrodes containing conductive oxides to produce light. But conductive oxides such as indium tin oxide have several limitations: they are expensive and come in scarce supply. ICFO Ph.D. student Danny Krautz, research fellow Stéphanie Cheylan, Ph.D. student Dhriti Sundar Ghosh, and group leader Valerio Pruneri have now validated thin nickel layers as an alternative coating with similar efficiency to indium tin oxide. The results were published last June in the Nanotechnology journal. "The successful entry of organic light-emitting diodes... into the general lighting market requires not just high-performance devices, but also a significant reduction in cost," the researchers noted in a Nanotechweb.org comment article.

business news

by Silvia Carrasco

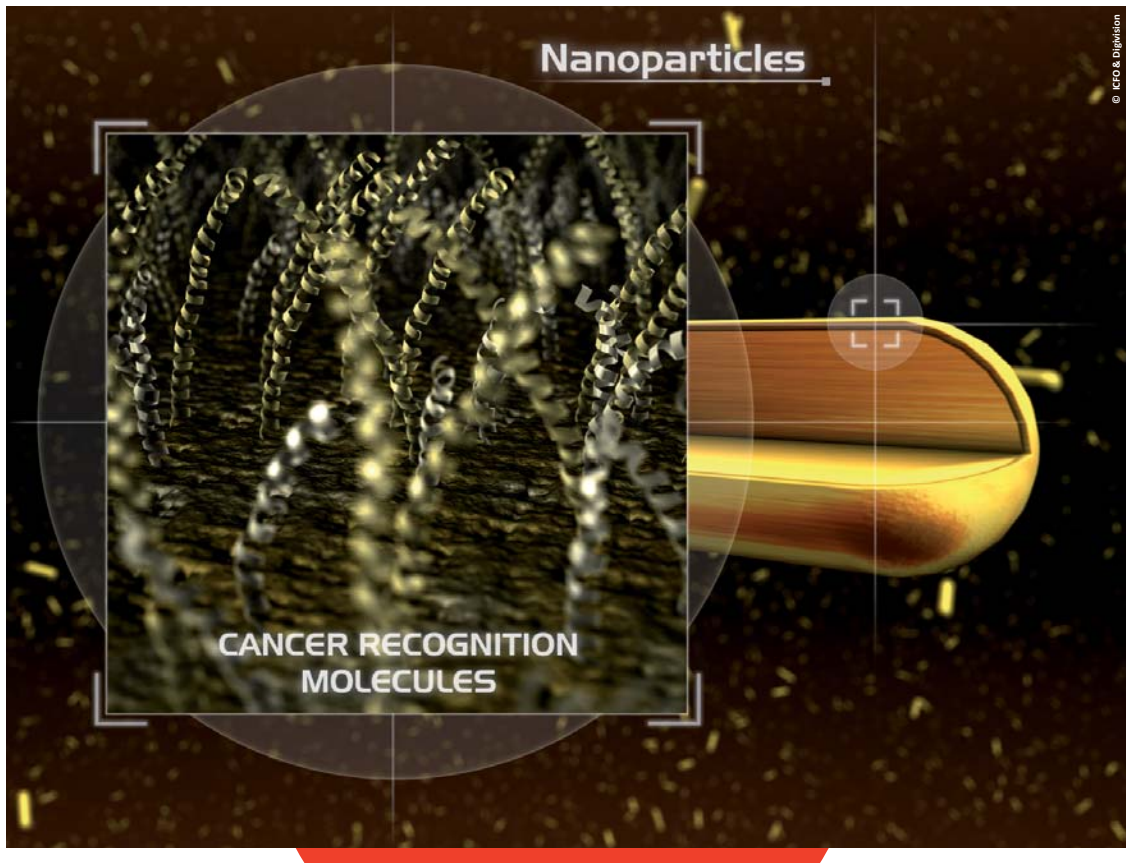
Light and Gold: Finding New Applications in Cosmetics

Nowadays, metal nanoparticles--ultra-small objects the size of a few nanometers (a nanometer being one millionth of a millimeter)--can be found both in the product pipeline of many pharmaceutical companies and in a variety of products already on the consumer market. The cosmetics sector in particular has been embracing the nanotechnology revolution taking place in our society today. Among the most common examples of cosmetic products already containing metal nanoparticles are sun filters based on titanium oxide and zinc nanoparticles.

Endor Nanotechnologies, a company funded in 2006 and with its headquarters in Barcelona, focuses on developing innovative biomedical solutions based on metal nanoparticles that have previously been coupled with biological molecules. With a well-defined biomedical portfolio promoting both diagnostic and therapeutic new approaches, Endor's Skin Care Division develops new cosmetic treatments using bio-conjugated metal nanoparticles as a tool for the release of active agents into the skin.

Since summer 2008, Endor and ICFO have been working together to put on the market a new way of understanding cosmetics. Adequately engineered gold nanoparticles activated with low-power laser light can act as efficient miniature sources of heat that are capable of stimulating biochemical processes in the skin in order to accelerate its regeneration. The joint research effort is supported by a grant from the local Government of Catalonia's funding agency ACC1Ó.

The ability to fully control the photo-thermal properties of such plasmonic nanostructures in a real biological environment is a sine qua non for the development of new cosmetic technologies based on this innovative concept. Together with his team, Romain Quidant, ICREA Professor, Cellex Fellow, and Group Leader at ICFO, has been contributing his expertise to the design, fabrication, and precise thermal control of the nanoparticles. This project requires the challenging real-time, non-invasive nano-mapping of minute as well as large temperature changes within skin cells under laser excitation. To date, the group has already developed a patented technology that represents the first reliable cell nano-thermometer available today.



The combination of light with gold nanoparticles coupled with biological molecules offer unprecedented potential in the development of new cosmetic products

Endor and Romain Quidant's Plasmon Nano-optics Group will now apply their know-how to the cosmetics sector. "Laser-nanoparticle interaction is a powerful technology platform with remarkable applications in life sciences. The dermatology and cosmetics markets offer many unexplored applications for this technology. There are already on the market some cosmetic products that utilize the gold structures' properties for transdermal drug delivery. Also, laser is widely applied in several skin treatments. The new products developed by Endor and ICFO aim to combine both technologies with completely novel results in order to become a new standard in dermatological and cosmetic treatments," says Joaquin Querol, Endor Nanotechnologies CEO.

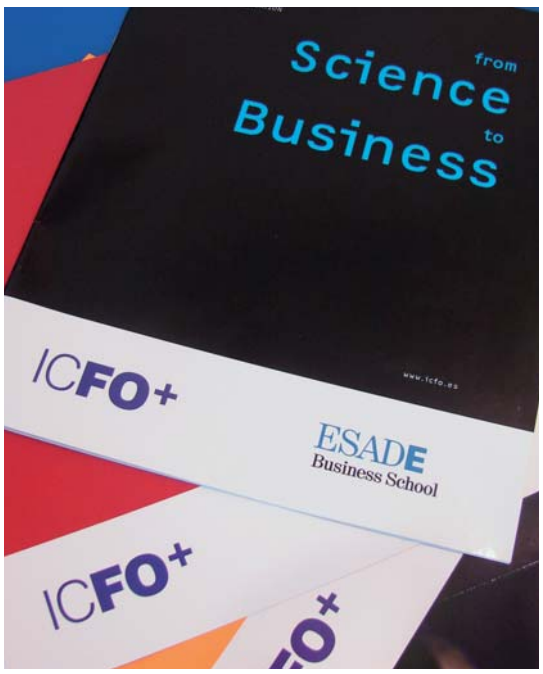
"Interestingly, we are exploiting here what researchers have for a long time considered a drawback of plasmonics, namely the heating of the metal. I am pretty convinced that the control of heat at the nanoscale using plasmonic nanostructures will have major applications in different fields, ranging from biomedicine to material sciences," adds Romain Quidant.

PEOPLE

in focus: from science to business

Nineteen ICFO Ph.D. students and postdocs took part in the latest ICFO-ESADE 'From Science to Business Week', which took place last May. Organized annually, the Business Week is the centerpiece of ICFO+, a training program in transferable skills offered to young researchers at ICFO. The four-day workshop teaches participants how to identify, evaluate, and pursue emerging technology venture opportunities, through lectures and case-study sessions imparted by professors of the Barcelona ESADE Business School.

This year's 'From Science to Business Week' was held in the nearby natural park of Montseny. "In a program like this, it is essential to create an inspiring and creative atmosphere that takes our minds away from the lab and opens us to new concepts and ways of approaching things," says ICFO Knowledge and Technology Transfer Director, Silvia Carrasco.



Gaining a Broader View

by Mafalda Almeida

Is it worth trading a week of productive scientific research for a week of intensive business training? That's an easy answer if you've already got that brilliant idea for a high-tech spin-off, which is definitely not my case. So, what could motivate me to participate in the 'From Science to Business Week'? For me, it was pure interest in listening to what professors from a top-ranked business school had to say about entrepreneurship and the powerful world of business. I went with an open mind and high expectations, after hearing some enthusiastic comments from initially skeptical former participants.

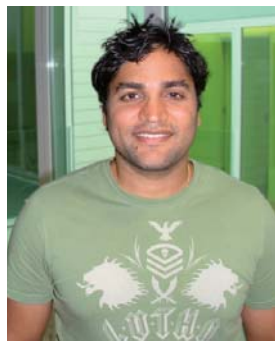
We started with a percussion workshop, which was great to break the ice and energize everyone for the following four days. The group was then ready to learn (and question!) the strategies large companies use to position themselves in the market; how to evaluate if a given product or service fulfils a need in society; the methods used to adequately reach the targeted consumers; how to start our own business; and, finally, how to use our safe world of formulas to evaluate the financial health of a company.

With all this, I've learned a great deal! The speakers were frankly good, energetic, and passionate about their work. I very much appreciated their honesty and correctness, which clashed with some existing stereotypes. And, on top of everything, we had good fun as a group! It was only four days, but I could sense a lot of companionship among all of us, which made our stay a very pleasant one indeed.

I do not know if I will ever become an entrepreneur, but this workshop made me realize how challenging it is to launch and run a successful company. Overall, it was a great experience, and I now just have become one more member of the highly enthusiastic community of former ICFO-ESADE Week's participants.

Discovering a New Culture

By Satish Rao



As we started the ICFO-ESADE Week, the course's objective soon became clear to me: to help the institute's young researchers bridge their knowledge gap between science and industry. I have conducted research in a number of different universities in the United States, yet never have I seen such an opportunity being offered to young scientists.

Every one of us who attended the workshop had a different experience. For some, it dispelled misconceptions about the essence and ethics of business. For others, simply seeing new opportunities outside the laboratory was enough to make the week a success. For me, that week was a thrill, mainly because it helped me realize that scientists have skills that can be transferred to business, provided they are willing to become students again.

The ESADE professors showed a lot of energy and did a good job of interacting with us during the lectures. Our group actively took part in all the sessions, though our interest may have become even more apparent during the discussions many of us continued having late in the evenings. The location could not have been any better, except perhaps for the arduous hike we took one day as a team-building activity!

What I took away from this week is some new-found business knowledge and a better understanding of what is required of us to transfer what we do in the lab to industry. I have also realized that such a process is actually quite simple, provided you show diligence.

Perhaps most importantly, I learned that scientists will always be scientists at heart. But like when living in a foreign country, we can learn to adapt to the business world and take advantage of it, should we want to.

community pictures

by Sandro Perrone

Left: (from left to right) Sandro Perrone, Alessandro Ferraro, Tristán Valenzuela, Javier Encomienda, Jürgen Eschner, and (below) Santiago Martín, during the 2008-09 awards ceremony of the 'Lliga Futbol Sala PMT'.

Right: ICFO players during a recent football tournament

The Football Team was founded by ICFO Group Leaders Antonio Acín and Jürgen Eschner, back in 2005. The team played its first game during the Castelldefels Campus League in 2006, winning the second place. A series of victories ensued that won the now-called Xenotof ICFO-FT Team the title of 2008-2009 champions (our trophies are in the coffee break area on the second floor).

We are looking for new players to join us this October. All that is required is motivation, and a love for the game!

ICFO Football Team

PEOPLE

ICFO-Caixa Catalunya summer fellows

For the third year running, the Caixa Catalunya-ICFO Summer Fellowship program allowed university students about to complete a first degree in science to experience frontier research on a firsthand basis. This year, ICFO welcomed 15 outstanding young scientists from the United States, Canada, Mexico, Germany, Poland, and Spain.

The Fellows, aged between 19 and 25, all worked on their own research project for three months under the supervision of an ICFO group leader. Project topics ranged from telecommunications, quantum information, and nanotechnology to biotechnology and photomedicine. In addition, the Fellows attended lectures on the fundamentals of light and laser applications imparted by ICFO researchers and invited guest speakers from other institutions. The Fellows' broader training program also included visits of ICFO's state-of-the-art laboratories.

"The Summer Fellowship Program is a fascinating opportunity for talented young people. The Program allows them to experience world-class and high-tech science in our field. Thanks to Caixa Catalunya's visionary support, we welcome young physicists, engineers, mathematicians, biologists, and chemists who are interested in finding out where the frontier lies in ICFO's spheres of knowledge," says ICFO Director Lluis Torner. "These Summer Fellowships are included within the line of work performed by Caixa Catalunya Social Services to enhance research, technological development, and innovation, as well as the momentum of new research talents," explained Caixa Catalunya Social Services Director Miquel Perdiguer.

"Our aim is for this experience to enrich the summer fellows personally and professionally and have a positive impact on their future careers," adds Silvia Carrasco, ICFO's Head of Knowledge and Technology Transfer.

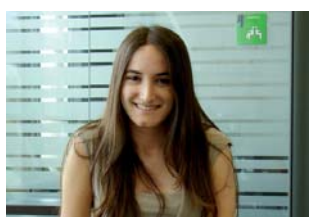
CAIXA CATALUNYA
OBRA SOCIAL

Francesc Espasa
Aged 25, Spain
Engineering Student
"The applications of photonics to medicine are my passion. To one day save lives with the help of science would be my dream come true."

Marduk Bolaños
Aged 23, Mexico
Physics Student
"This is a much more productive approach. I started to learn and to work from my very first day at ICFO."

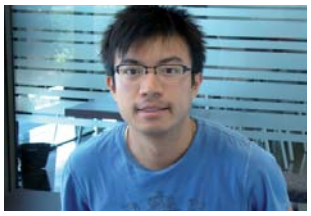
Gonzalo de la Torre
Aged 23, Spain
Physics Student
"I would like to explore the applications of quantum information. Maybe some day I'll be able to start my own high-tech company."

Siamrut Patanavanich
Aged 23, United States
Engineering Student
"In the U.S.A. every researcher works by himself, while at ICFO you get the chance to talk to everybody in a relaxed and stimulating environment."



Laura Dubreuil
Aged 21, Spain
Engineering Student
"This isn't just another summer job: I'm here to enjoy every minute."

Anna Przysiezna
Aged 24, Poland
Physics Student
"The location of Barcelona is a great incentive for this experience."



Herman Wong
Aged 23, Canada
Engineering Student
"ICFO has found the right balance between the corporate world and academia."

Martí Perarnau
Aged 20, Spain
Physics Student
"I wanted to experiment research firsthand."

Avelino Javer
Aged 24, Mexico
Engineering Student
"Administrative support at ICFO is excellent: you can devote yourself to research fulltime."

David Frigola
Aged 23, Spain
Physics Student
"This experience will help me to choose between my two passions: biophysics and astrophysics."

Eliot Hijano
Aged 19, Spain
Physics Student
"In the future, I would like to go to the U.S.A. and do research in the field of quantum mechanics."

Sebastian Knorr
Aged 24, Germany
Engineering Student
"Even if I go and work for a company, I want to learn how the things I make function."

Yulia Tolstova
Aged 21, United States
Engineering Student
"I've already had a summer job, but this is different."

Francisco Cordobés
Aged 23, Spain
Physics Student
"I wanted to see what a real lab is like."

Roberto León
Aged 24, Mexico
Physics Student
"I've made up my mind: I'm going to do a Ph.D. in physics."

ICFO at E^2C^3

A group of ICFO researchers took part in this year's E^2C^3 ('Estades d'Estiu de Ciència Caixa Catalunya'), a summer school run annually by the Caixa Catalunya Obra Social as part of its 'Joves i Ciència' Program and the local Catalan government. E^2C^3 summer schools aim to expose outstanding and motivated high school pupils to scientific research with a view to promote research careers among young people.

Among the ICFOnians involved in E^2C^3 this year were Ph.D. students Manoj Mathew, Giorgio Volpe, and Sandro Perrone, postdoctoral researcher Alejandra Valencia, and Giovanni Volpe, a former ICFO Ph.D. student now doing a postdoc at the Max Planck Institute in Stuttgart, Germany.

Together, these ICFO researchers guided a team of 12 high school pupils through the discovery of light and its properties for 12 days. They organized a hands-on workshop, called 'Pick it up with light!', in which they helped pupils build an experimental setup for optical tweezing (actually not that different from those found in real, state-of-the-art research labs). The E^2C^3 summer school took place in the superb natural environment of Planes de Son in the Pyrenees in early July.

Courtesy of Manoj Mathew

High school pupils discovered light and its properties during an E^2C^3 workshop this summer

PERSPECTIVES

beyond the lab

Optics & Photonics Focus (OPFocus) is an independent magazine that has for objective to highlight new optics and excellent photonics research. It was launched in June 2008 by a group of young researchers at ICFO willing to improve communication between different disciplines in the fields of optics and photonics and to contribute to the dissemination of science to a wider public. OPFocus reviews a broad range of current research findings for fellow scientists and provides new insights for lay people and journalists.

The Optics & Photonics Focus editors are Giovanni Volpe (now at the Max Planck Institute in Stuttgart, Germany), Armand Niederberger, Giorgio Volpe, and Manoj Mathew.

What a Molecular Transistor!

by Giorgio Volpe

How far can a single, tiny molecule go? Exceeding most people's imagination, researchers have now shown that a single molecule can actually function just like a transistor does.

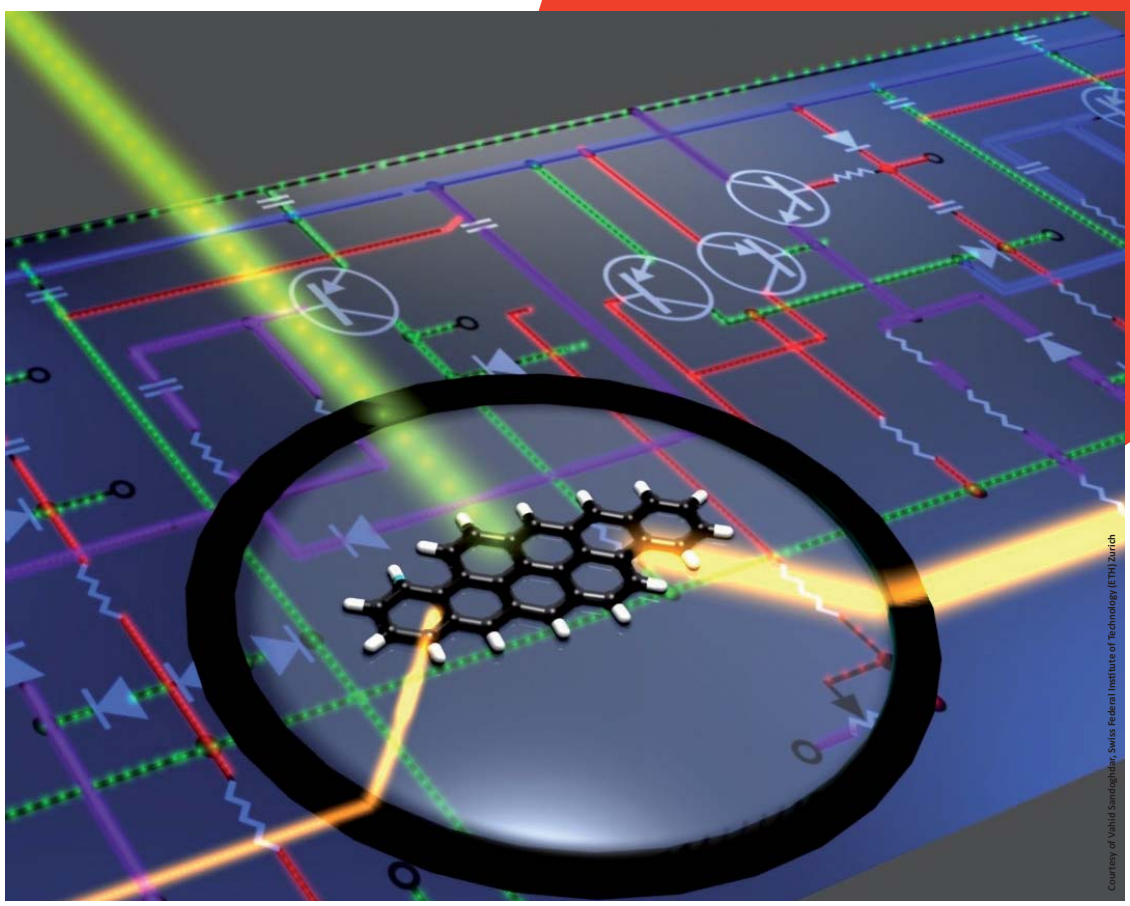
What is the major technological breakthrough of the 20th century? According to the U.S. National Academy of Engineering's top 20 list, electronics, computers, lasers, and optical communication are all good candidates. But these have something in common: they all rely on transistors. Vahid Sandoghdar and the Nano-optics group at the Swiss Federal Institute of Technology (ETH) Zurich, Switzerland have now shown that single molecules are able to perform on photons all the operations that standard transistors routinely perform on electrons--a huge step towards building a new generation of computers and other devices finally able to use light instead of electricity.

The transistor is the fundamental building block of almost all electronic equipment today. Transistors are used to control the flow of electrons that make electrical signals. When powered by a small-intensity current, a transistor is able to function as a gate that controls a flow of electrons in an incoming electrical signal of great intensity, in the same way as valves control water flow in taps. When the powering current reaches a certain threshold, the gate opens and lets the large incoming electrical flow go through. Below that threshold, the gate shuts down. The job of the transistor is therefore to amplify or attenuate a large incoming electrical signal compared with a low-intensity powering current.

Another way of seeing transistors is as binary switches: an open gate can be encoded as a digital 1 for example, with a closed gate becoming a digital 0. Transistors are thus a key component in electronic devices such as computers, because they can be arranged into networks and perform all kinds of binary operations.

optics & photonics focus

A molecular integrated circuit. An artistic representation of a fully optical circuit using single molecule optical transistors as building bocks. In the black circle, a molecule is amplifying an incoming light signal (yellow) in the same way as a transistor amplifies electronic signals. The control over the amplification is given by a lower-intensity light beam (green)



Nonetheless, "these basic operations … when performed with electrons, present limitations, such as losses, heating, and cross-talks between electrons. It would be interesting if the same operations could be performed using light," says Vahid Sandoghdar. The main advantage of light is that it is faster than anything else, and using photons instead of electrons could greatly speed things up. "This opens new difficulties, though. Controlling light by using light is not possible, since photons do not interact among themselves," Sandoghdar adds.

Sandoghdar and his team at ETH have now overcome this challenge by using single molecules to mediate interactions between photons. Molecules can thus emit light in a process called stimulated emission: when bombarded with photons of the correct energy, electrons within a molecule can reach an excitation state, eventually coming back to normal after releasing new, identical photons. However, "stimulated emission in molecules is usually an inefficient process... By going to low temperature in order to increase the molecular cross-section and by focusing light to diffraction limit, we achieved the higher efficiency needed to perform our experiment," Sandoghdar says.

Within those conditions, the researchers were able to apply two different sources of laser light to make single molecules behave just like transistors. They used an incoming laser whose photons could have one of two effects on molecules--either propel the molecules' electrons into an excitation state or excite those electrons and also trigger the release of photons by the molecules. What determined which effect the incoming laser had was the use of another, low-intensity laser: when the low-intensity laser was applied, the incoming laser coaxed molecules into emitting new photons. When the low-intensity laser was switched off, the incoming laser only became able to excite the molecules' electrons.

"Three actions are, therefore, possible on the [incoming] beam, i.e. to attenuate it up to ten percent, leave it unaltered, or amplify it up to one percent," Sandoghdar says. This may seem low, but in other non-linear light phenomena, "usually not more than one photon out of a million is affected. The efficiency achieved in this work is incredibly high since you can control nearly all the photons of a light beam this way," says Diederik Wiersma, who heads the Optics of Complex Systems group at the European Laboratory for Non-linear Spectroscopy in Florence, Italy.

The ETH researchers expect a long way to go before seeing any practical applications to their findings. For example, "wiring at the nanometer scale will be something that has to be figured out in order to make such optical transistors communicate among themselves," admits Sandoghdar.

Still, "it is impossible to know all the applications that can come out of an important scientific result," Wiersma says. Back in those early days when the first electronic transistor was built, it was so big that it seemed impossible to ever scale it down to the centimeter and make it as useful as it is today. "It might be that, one day, we could use these single molecule optical transistors as building blocks for creating fully optical circuits."

But, meanwhile, it's important to "not forget… to look also at the shear beauty of the result as such: these researchers managed to block and control a beam of light with one single molecule, which is a really exceptional achievement," Wiersma adds.

To keep abreast of exciting new developments in the fields of optics and photonics, visit the OPFocus web site at www.opfocus.org

THE LAST WORD

high profile

Dr. Michael Heckmeier is Director of the Chilworth Technical Centre in Southampton, England within the Merck Group's Chemicals Business Sector. Dr. Heckmeier has a Ph.D. in physics and an MBA, and has numerous publications under his name in the field of polymers, colloids, and liquid crystals. He also holds several patents related to the applications of these materials in the field of optics and electronics

Q: Where do Merck's interests lie in the field of optics and photonics?
A: These materials that we're working on for optical applications are a long tradition at Merck. Merck is the market leader in liquid crystals for displays, [ranging] from notebooks, monitors, TVs, to mobile phones. The next wave in chemicals for displays might be OLEDs, and now we have more than 100 researchers in this OLED field. Merck also has a very established product range in photovoltaics already and is moving also toward the next generation of photovoltaics, which are organic photovoltaics.

Q: What fascinates you in this field?
A: The first thing is really, whatever you do, you can see it. It's optics, so there's a visual effect to it and even to my two young sons, I can easily explain what I'm doing. Second thing is I think we really work on topics that could change the whole game of the industry, and that is really strongly motivating and challenging.

Q: How did you get to work in this field?
A: I'm a physicist by training and I worked on light scattering for both a Master's thesis and a Ph.D. Fundamental understanding of things is very important, but in addition I wanted to get the feeling that my work is leading to something that people can use. It was about 10 years ago when I started at Merck in the liquid crystal display activity as a bench scientist. Eventually, I became a lab manager, and then moved on to a more international project. Then, about five years ago, I moved out of liquid crystals to start new projects about solid state lighting and printed electronics. The future will be printed solar cells, foldable displays, and printed transistors, and we are making the materials to make this happen.

Q: What are the main differences between academia and industry?
A: Even though we try to give our scientists a lot of freedom, it's less freedom than in academia. In industry, it's a bit more of a structured approach: there's a lot of project work, there's also a stronger confidentiality aspect to all the activities. The good thing is that if you work on a hot topic with huge future business potential in a big company, you can enjoy a lot of funding and support. You can work on topics much quicker and much more efficiently than in the academic environment, where you typically spend a lot of time convincing funding bodies.

Q: What qualities are you looking for in young scientists when recruiting?
A: We plan to increase our team's size, so we are building future labs. It's important of course that people come with a very solid background in the fields we are working in. And then, it's key for us that they fit in with the team, so these people have to present in front of the whole team they would be part of in the future. We also look at soft skills like communication and maybe potential for future leadership tasks.

Q: Any advice for young scientists interested in entering the industry?
A: They should not listen to too many people, but really listen to themselves, to what they really want to do. When you start something, after five years, the industrial world looks very different, so being excited and really passionate for a topic is much more important than the topic as such.

During his short visit to ICFO, Dr Michael Heckmeier gave a talk on 'Functional Materials for Printed Electronics and Photovoltaics' as part of the ICFO Colloquium series. Dr Heckmeier also answered young scientists' questions in a coffee session organized by the ICFO Organization and Network of Students (ICONS)

sudoku

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